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Gravity Wave Emission by Spontaneous Imbalance of Baroclinic Waves in the Continuously Stratified Rotating Annulus

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We use a numerical model of the classic differentially heated rotating annulus experiment to study the spontaneous emission of gravity waves (GWs) from jet stream imbalances, which is a major source of these waves in the atmosphere for which no satisfactory parameterization exists. Atmospheric observations are the main tool for the testing and verification of theoretical concepts but have their limitations. Given their specific potential for yielding reproducible data and for studying process dependence on external system parameters, laboratory experiments are an invaluable complementary tool. Experiments with a rotating annulus exhibiting a jet modulated by large-scale waves due to baroclinic instability have already been used to study GWs: Williams et al (2008) observed spontaneously emitted interfacial GWs in a two-layer flow, and Jacoby et al (2011) detected GWs emitted from boundary-layer instabilities in a differentially heated rotating annulus. Employing a new finite-volume code for the numerical simulation of a continuously stratified liquid in a differentially heated rotating annulus, we here investigate whether such an experiment might be useful for studies of spontaneous imbalance. A major problem was the identification of experimental parameters yielding an atmosphere-like regime where the Brunt-Vaisala frequency is larger than the inertial frequency, so that energy transport by the lowest-frequency waves is predominantly horizontal while high-frequency GWs transport energy vertically. We show that this is indeed the case for a wide and shallow annulus with relatively large temperature difference between the inner and outer cylinder walls. We also show that this set-up yields a conspicuous signal in the horizontal divergence field close to the meandering jet. Various analyses support the notion that this signal is predominantly due to GWs superposed on a geostrophic flow.

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